

DIURNAL VARIATION OF RAINFALL AT SAN JUAN, P. R.¹

C. L. RAY

[Weather Bureau Office, San Juan, Porto Rico]

In the following notes are given the hourly frequencies of rainfall, based upon the 23-year record (1905 to 1927) at San Juan, P. R. These are shown for the several months and year. The results are offered not so much with the idea of adding to the subject as covered in studies of Dr. O. L. Fassig² as to incorporate into the latter data the records of the additional 10 years that are now available. San Juan is in some respects distinguished by an oceanic as well as tropical climate. This is particu-

night maximum frequency throughout the year, there is a primary maximum in the afternoon hours, also characterized by a greater intensity per shower.

In the month of December occurs the maximum frequency of the year (17) for a single hour, from 4 to 5 a. m.

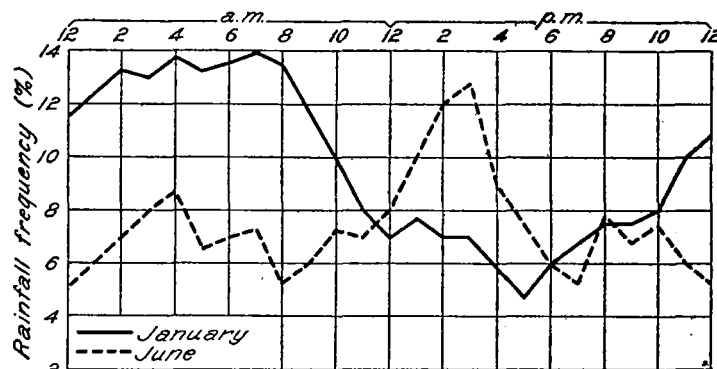


FIG. 2.—Hourly frequency of rainfall, San Juan, P. R., 1905-1927

with a secondary maximum of 16 per cent from 1 to 2 a. m. The least frequency for the month is 5.9 per cent, occurring from 4 to 5 p. m. From these figures it may be said that there is a three times greater chance, during December that rain will fall between 2 and 5 a. m. than from 2 to 5 p. m. The least frequency for the year is 2.8 per cent from 11 to 12 noon in March.

In Figure 2 is shown the January and June hourly frequency and in Figure 3 the annual hourly frequency and hourly intensity.

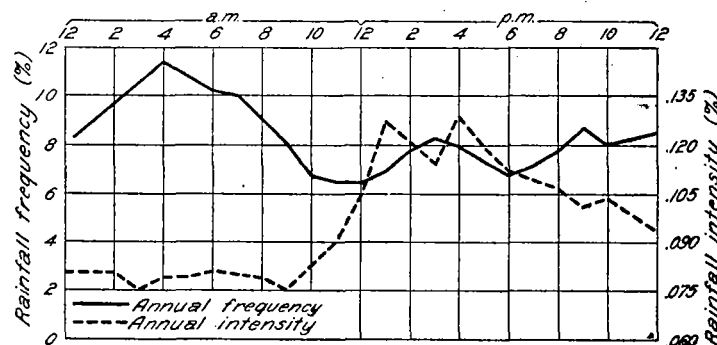


FIG. 3.—Annual hourly frequency and intensity of rainfall, San Juan, P. R., 1905-1927

the period from 1 to 4 p. m. as compared with the maximum frequency from 2 to 5 a. m. A comparison of the frequency and depth of rainfall in Tables 2 and 3 shows, however, a rather close agreement between the two, in certain months. For example, in the January, February, December period there is a maximum frequency and maximum accumulated amount of rain in the six hours 1 to 6 a. m., with each of the other three six-hour periods in agreeing order, the least frequency and least amount occurring from 12 noon to 6 p. m. From April to October, on the other hand, there is a shift in the maximum amount of rainfall to the period from noon to 6 p. m. which is not in every instance balanced by a similar change in frequency. A better comparison is possibly obtained by taking two 12-hour periods, from 6 p. m. to 6 a. m. and from 6 a. m. to 6 p. m. In this arrangement we have the six months, January, February, March, June, November and December, in agreement, with both

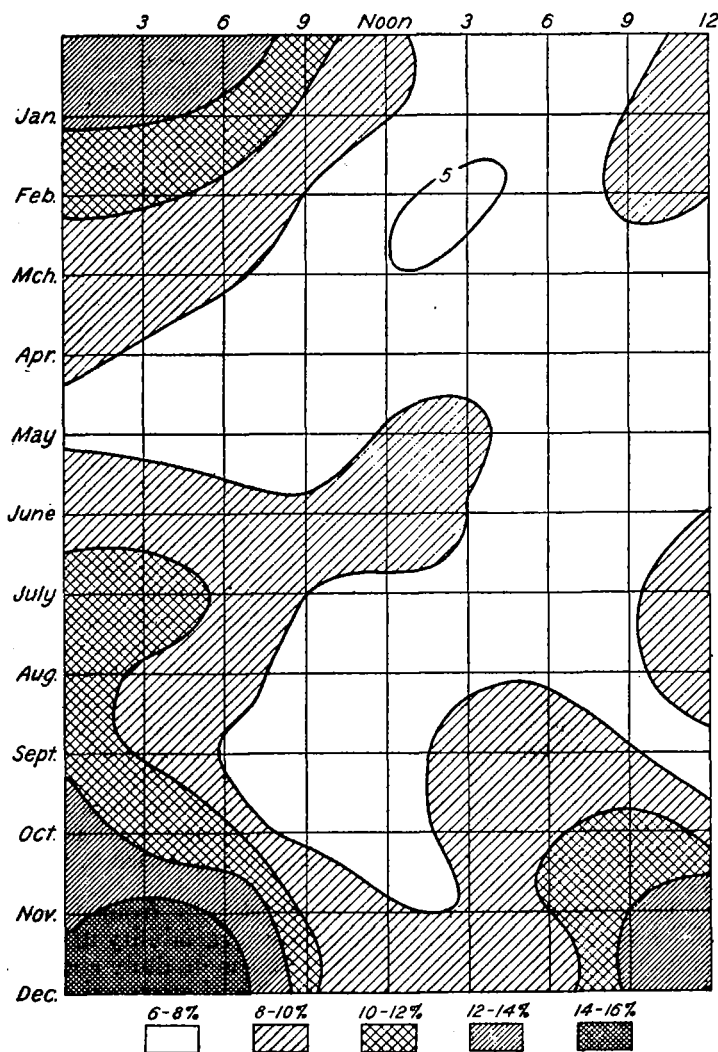


FIG. 1.—Three-hour rainfall frequency (1905-1927), San Juan, P. R.

larly noted in the predominance of night rainfall frequency. The same has been found to be true also of Honolulu, Hawaii, as shown in the paper of Loveridge.³ In Table 1, in the present paper, is given the hourly frequencies at San Juan and in Figure 1 is given a graph of these results. As will be noted, there is a maximum night frequency in January, February and March, April, July, August, November, and December, with secondary maxima in May, June, September, and October. In these latter months, which break the otherwise continuous

¹ Cf. Fassig, Tropical Rains, Their Duration, Frequency and Intensity. MONTHLY WEATHER REVIEW, vol. 44, June, 1916, p. 329, etc.

² MONTHLY WEATHER REVIEW, 52: 584.

³ Loveridge, Diurnal Variation of Precipitation at Honolulu. MONTHLY WEATHER REVIEW, vol. 54, December, 1924, p. 585, etc.

frequency and amount reaching a maximum in the night hours with the exception of June, during which month both fall in the day period. In April both frequency and

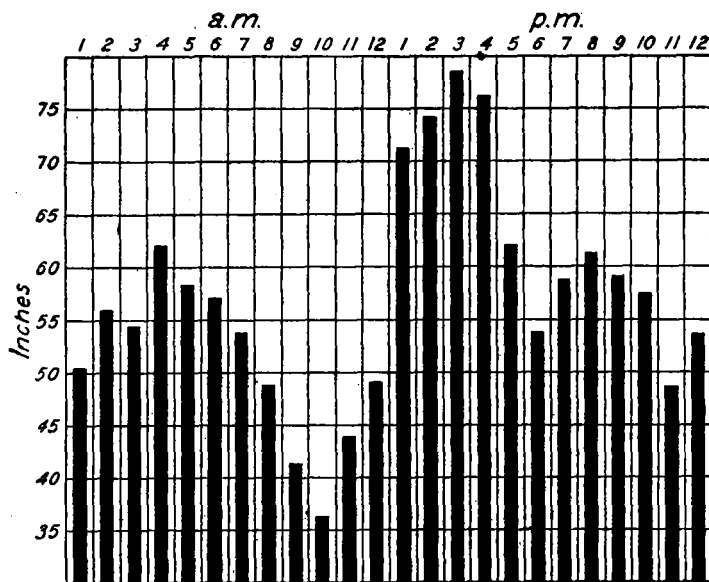


FIG. 4.—Annual accumulated hourly rainfall, San Juan, P. R., for 23 years, 1905-1927, inclusive

amount are about equally divided between night and day. In May there is a 50-50 frequency but 14 per cent greater amount falling in daytime hours. In July, August, and

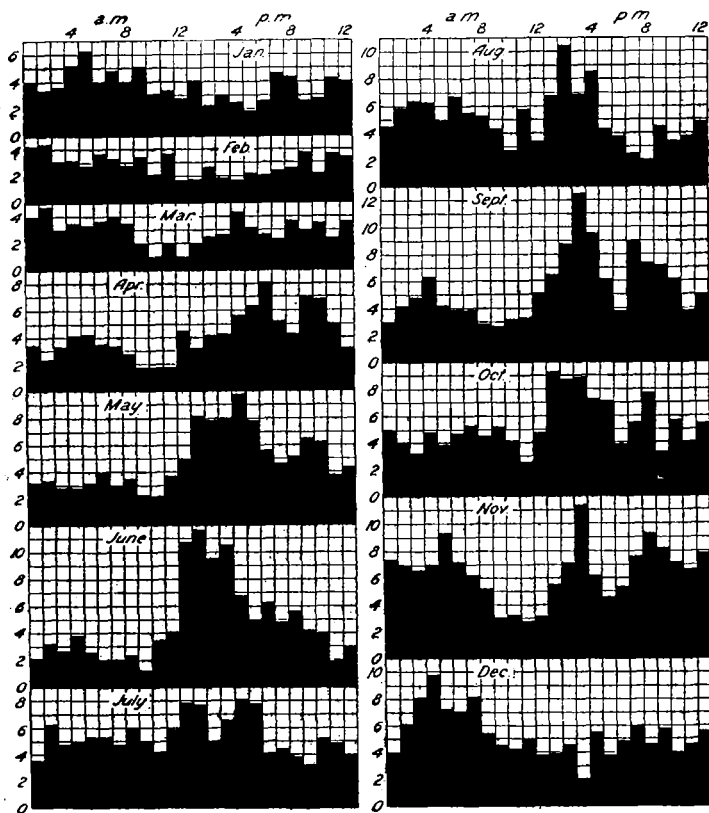


FIG. 5.—Accumulated amounts of rainfall, San Juan, P. R., for 23-year period, 1905-1927, inclusive

September the 12-hour day period receives from 8 to 12 per cent greater amounts of precipitation than night hours, while the frequency is divided practically 50-50 between night and day. In October both frequency and amount are almost equally divided.

Accumulated amounts for the 23 years as occurring for each hour are shown in Figure 4. A maximum of 79.15 inches has been recorded for the hour 2 to 3 p. m. and 75.59 inches from 3 to 4 p. m. while the least accumulated amount was 36.19 inches from 9 to 10 a. m. In Figure 5 the monthly accumulated amounts are shown to agree with the annual trend, particularly from April through November, while in the winter months a shift in the maximum amounts from afternoon to early morning hours occurs.

An interesting comparison is afforded in the hourly frequencies of the rainfall at Honolulu. In the annual frequency for that station there occurs a small secondary maximum at 8 p. m., comparing with a similar secondary maximum at 9 p. m. at San Juan. The frequencies at Honolulu, however, show a much lower afternoon percentage than occurs at the Caribbean station, where during several months of the year are recorded maximum frequencies for the 24 hours in the afternoon period. The monthly proportion between maximum and minimum frequency is as high as 8 to 1 at Honolulu, but does not quite attain a 4 to 1 range in the most extreme instance at San Juan, and as a rule does not exceed a 2 to 1 variation. The predominance of the maximum night frequency is pronounced at both stations, however.

TABLE 1.—Hourly frequency of precipitation, San Juan, P. R. (1905-1927)

| | A. M.—hour ending at— | | | | | | | | | | | |
|----------------|-----------------------|------|------|------|------|------|------|------|------|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| January..... | 12.6 | 13.7 | 13.0 | 14.1 | 13.7 | 13.9 | 14.0 | 13.9 | 10.8 | 8.6 | 7.7 | 7.2 |
| February..... | 9.2 | 10.8 | 10.3 | 10.7 | 11.8 | 10.8 | 9.8 | 11.2 | 11.2 | 7.1 | 6.5 | 5.1 |
| March..... | 8.6 | 10.0 | 9.1 | 9.1 | 10.0 | 10.5 | 10.7 | 10.0 | 8.0 | 4.3 | 4.2 | 2.8 |
| April..... | 6.2 | 8.8 | 8.0 | 9.0 | 7.4 | 7.8 | 7.5 | 6.8 | 5.8 | 4.6 | 5.0 | 5.7 |
| May..... | 4.2 | 6.6 | 8.3 | 8.1 | 8.1 | 6.9 | 7.5 | 6.6 | 6.7 | 6.1 | 4.9 | 6.9 |
| June..... | 6.1 | 7.1 | 8.4 | 8.3 | 6.2 | 6.7 | 7.4 | 4.6 | 5.4 | 7.7 | 7.0 | 8.1 |
| July..... | 9.5 | 10.0 | 10.7 | 11.4 | 11.1 | 9.5 | 10.0 | 8.6 | 9.1 | 7.3 | 7.3 | 8.1 |
| August..... | 8.5 | 10.8 | 14.0 | 12.6 | 11.4 | 11.3 | 10.0 | 9.0 | 7.2 | 6.1 | 7.7 | 6.1 |
| September..... | 8.8 | 8.1 | 8.1 | 9.7 | 9.4 | 7.0 | 7.8 | 7.1 | 5.5 | 5.8 | 5.5 | 6.7 |
| October..... | 10.0 | 8.8 | 8.8 | 9.4 | 7.7 | 9.0 | 8.0 | 8.6 | 6.6 | 4.9 | 3.7 | 6.3 |
| November..... | 12.8 | 13.3 | 13.0 | 12.6 | 14.1 | 13.5 | 12.5 | 10.1 | 8.0 | 6.4 | 5.9 | 6.7 |
| December..... | 14.2 | 16.0 | 14.3 | 16.1 | 17.0 | 13.9 | 15.8 | 13.3 | 13.1 | 8.0 | 9.6 | 7.2 |
| Annual..... | 9.2 | 10.2 | 10.5 | 10.9 | 10.7 | 10.1 | 10.2 | 9.2 | 8.1 | 6.4 | 6.2 | 6.4 |

| | P. M.—hour ending at— | | | | | | | | | | | |
|----------------|-----------------------|------|------|------|------|-----|------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| January..... | 8.1 | 6.7 | 6.7 | 5.6 | 5.1 | 6.6 | 6.6 | 8.0 | 7.6 | 8.0 | 9.8 | 11.5 |
| February..... | 6.2 | 6.0 | 5.2 | 5.1 | 4.8 | 4.8 | 6.3 | 6.3 | 8.0 | 7.2 | 9.7 | 8.0 |
| March..... | 3.8 | 4.9 | 4.2 | 4.6 | 4.8 | 5.3 | 6.2 | 6.7 | 7.3 | 5.3 | 5.9 | 6.9 |
| April..... | 6.1 | 5.0 | 6.7 | 6.8 | 7.1 | 5.9 | 5.9 | 5.4 | 6.1 | 5.8 | 6.1 | 4.1 |
| May..... | 9.4 | 9.5 | 10.4 | 9.4 | 9.1 | 6.7 | 6.3 | 5.9 | 7.5 | 6.9 | 6.9 | 6.5 |
| June..... | 9.6 | 12.8 | 10.4 | 8.7 | 6.2 | 5.7 | 7.7 | 7.3 | 7.1 | 7.7 | 6.2 | 5.7 |
| July..... | 8.7 | 8.0 | 8.3 | 7.6 | 6.9 | 6.1 | 6.9 | 6.1 | 6.9 | 8.8 | 7.3 | 8.3 |
| August..... | 8.0 | 9.3 | 8.6 | 9.3 | 6.1 | 5.9 | 6.6 | 5.8 | 9.3 | 7.2 | 7.4 | 9.7 |
| September..... | 7.5 | 8.7 | 10.2 | 10.9 | 8.8 | 6.7 | 7.8 | 9.4 | 9.6 | 8.8 | 7.1 | 7.1 |
| October..... | 8.0 | 9.9 | 9.0 | 9.9 | 10.5 | 8.5 | 7.5 | 8.6 | 8.0 | 7.2 | 8.7 | 9.4 |
| November..... | 8.0 | 9.7 | 9.6 | 8.8 | 8.8 | 9.1 | 11.2 | 11.6 | 13.7 | 11.4 | 11.4 | 11.8 |
| December..... | 6.6 | 6.7 | 6.1 | 7.7 | 5.9 | 8.8 | 10.7 | 12.0 | 12.2 | 10.5 | 12.1 | 11.8 |
| Annual..... | 7.5 | 8.1 | 8.0 | 7.8 | 7.0 | 6.7 | 7.5 | 7.8 | 8.6 | 7.9 | 8.2 | 8.3 |

TABLE 2.—Six-hour apportionment of rainfall frequency, San Juan, P. R. (1905-1927)

| | A. M. | | P. M. | | | A. M. | | P. M. | |
|---------------|-------|------|-------|------|----------------|-------|------|-------|------|
| | 12-6 | 6-12 | 12-6 | 6-12 | | 12-6 | 6-12 | 12-6 | 6-12 |
| January..... | 13.5 | 10.4 | 6.5 | 8.6 | August..... | 11.4 | 8.4 | 7.9 | 7.7 |
| February..... | 10.6 | 8.4 | 5.4 | 7.6 | September..... | 8.5 | 6.4 | 8.8 | 8.3 |
| March..... | 9.7 | 6.7 | 4.6 | 6.4 | October..... | 9.0 | 6.4 | 9.3 | 8.2 |
| April..... | 7.5 | 5.9 | 6.3 | 5.6 | November..... | 13.2 | 8.3 | 9.0 | 11.8 |
| May..... | 7.3 | 6.4 | 9.1 | 6.5 | December..... | 15.2 | 11.2 | 7.0 | 11.6 |
| June..... | 7.1 | 6.7 | 8.9 | 7.0 | Annual..... | 8.8 | 7.8 | 7.5 | 8.0 |
| July..... | 10.4 | 8.4 | 7.6 | 7.4 | | | | | |

TABLE 3.—Six-hour apportionment of rainfall amounts (per cent), San Juan, P. R. (1905-1927)

| | A. M. | | P. M. | | | A. M. | | P. M. | |
|---------------|-------|------|-------|------|----------------|-------|------|-------|------|
| | 12-6 | 6-12 | 12-6 | 6-12 | | 12-6 | 6-12 | 12-6 | 6-12 |
| January..... | 31 | 26 | 17 | 26 | August..... | 28 | 22 | 33 | 17 |
| February..... | 31 | 25 | 18 | 26 | September..... | 20 | 16 | 36 | 28 |
| March..... | 31 | 19 | 25 | 25 | October..... | 20 | 20 | 35 | 25 |
| April..... | 21 | 16 | 31 | 32 | November..... | 29 | 15 | 26 | 30 |
| May..... | 17 | 17 | 40 | 26 | December..... | 33 | 24 | 19 | 24 |
| June..... | 15 | 22 | 43 | 20 | Annual..... | 25 | 20 | 30 | 25 |
| July..... | 24 | 26 | 30 | 20 | | | | | |